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Seed Coating with Organomineral Fertilizer, An Alternative Method to Improve the Efficiency of Farming

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ABSTRACT

Seed and fertilizer are two important farming inputs, which are commonly available and used separately. Combining both materials into a unit of fertilizer-coated seed may improve farming efficiency. Technically, however, the appropriate seed coating method must be found out, and this research was the first effort of finding the method. A glasshouse experiment was carried out to identify the growth and yield of the coated seeds of rice and groundnut with organomineral fertilizer in three different sizes (i.e., small (SS), medium (MS), and big sizes (BS). Four sets of experiments were prepared, two of those were for testing two varieties of rice, and the others were for testing two varieties of groundnut. Each experiment was laid out in a complete randomized design; the treatment was the size of coated seeds (SS, MS, BS, and a control - uncoated seeds) in triplicates. Results reveal that the seed coating delayed the germination of rice seeds for 2 – 3 days and groundnut seeds for 7 – 16 days. The coating also suppressed the growth and yield of rice but improved the growth and yield of groundnut. The coated seeds of groundnut producing the higher yield were the small and medium sizes (the weight ratios of seed:coating material were 1:4 and 1:9). In case of rice seeds, the reduces of growth and yield of the coated seeds were most probably due to the direct contact of the high concentration of nutrients, especially nitrogen, dissolved from the coating material with the seeds. In conclusion, the seed coating with organomineral fertilizer improve the yield of groundnut, and the best coating was in small to medium sizes. Especially for coating the rice seeds, further efforts were needed to fix the composition of organomineral fertilizer, especially the type N substances used, and the steps of applying the materials onto the seeds.

Keywords: organomineral fertilizer, coating materials, seed coating, silicate rock fertilizer

1. INTRODUCTION

Seed and fertilizer are two vital inputs in the farming of crops grown from seed, such as rice (*Oryza sativa* L.) and groundnut (*Arachis hypogaea* L.). The current issue of farming technology relating to the seeds is seed coating, and of that for fertilizer is the utilization of the natural sources of plant nutrients, including silicate rocks. Combining those farming inputs into a unit material, which is coating the seeds with the fertilizer, may be an appropriate method to improve the productivity and profitability of the farming.

Seed coating is an important technology that has been applied by seed industries for decades. The industries use various coating materials, and the most common one is pesticides [1]. The main aims of using pesticides are to suppress, control, or repel the soil-

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borne pathogens, insects, and other pests attacking seeds, seedlings, or plants [2, 3]. However, exposing pesticides into farming land may potentially develop pest resistance and create various negative-ecological effects [4]. Thus, it is a challenge for the seed industries to find out and use the more environmentally sound coating materials.

Fertilizer is another important farming input, used to fulfill the optimum requirement of crops for essential nutrients. The appropriate fertilizer application, referring to the ideal concept of proportional fertilization, however, is often difficult to be applied on the farm level, especially by small farmers in developing countries, due to technical or/and economic constraints. The high variability of soil properties, for example, may cause the difficulties to define the appropriate rate of fertilizer application; and the lack of farming capital often limits the small farmers to access the appropriate quantities of synthetic fertilizers. Responding to the cases, many researchers [5, 6, 7, 8] proposed the utilization of natural sources of plant-nutrients, e.g., silicate rocks, as cheap and environmentally sound fertilizer. However, the use of silicate rock fertilizers (SRFs) was limited in farming practices due to the very slow release of nutrients from the SRFs. Consequently, the farming required very high doses (> 20 t.ha^{-}) of SRFs [7]. However, by employing ball milling in producing SRFs [9, 10], or/and mixing SRFs with organic matter (organomineral fertilizer), significantly improved the effectiveness of SRFs [11].

The limitations of the seed coating and fertilizer application described above inspired us to propose combining the seed with organomineral fertilizer into the organomineral-coated seeds as an alternative solution for the farming constraints. The organomineral fertilizer consisted mainly of SRFs, phosphatic rocks (PRs), and organic matters (OM), and those materials were coated onto the seeds and intended to sufficiently fulfill the optimum requirement of essential nutrients for the without additional fertilizers. Planting the organomineral-coated seeds maybe also reduce the farming cost with less negative-environmental effects, and improve soil quality due to the residual effects of the coating materials (organomineral fertilizer) remaining in the soil.

This research was the first attempt to evaluate if the proposed farming method described above was realistic. The main objective of this research was to identify the effects of seed coating with organomineral fertilizer on the growth and yield components of rice (*Oryza sativa* L) and groundnut (*Arachis hypogaea* L).

2. MATERIAL AND

2.1. Seeds and Coating Materials

The seeds of two varieties of rice, i.e., Impari 32 and Bunda Sri Madrin (BSM), and two varieties of groundnut, i.e., Lombok and Kelinci, were prepared. The coating materials for rice seeds were SRF (87.5 % w/w), PR (4 % w/w), urea (4 % w/w), OM (2 % w/w), and liquid-foliar fertilizer (trademarked as Orrin) (2.5 % v/w). The SRF, PR, and OM were mixed, while urea was dissolved into Orrin that was functioned as the binding substance. The coating materials for groundnut seeds were the same as those for rice seeds, but the urea was substituted with $CaCO_3$ (4 % w/w) added to the mixture of SRFs + PRs + OM, and the binding substance for the coated seeds was only Orrin.

The SRF was the finely ground basaltic rocks from Rinjani Mt. in Lombok Island – Indonesia. The rocks were mechanically broken to Ø < 1 cm and then ball-milled for 40 minutes producing the SRF-powder with the median diameter (D_{50}) $\leq$ 5.4 μm. The chemical composition of the SRF-powder was 52.28 % SiO_2, 24.12 % Al_2O_3, 4.82 % CaO, 1.83 %

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4.28 % K_2O, 2.30 % Na_2O, 6.24 % FeO, 0.15 MnO, 0.01 % ZnO, 0.30 % CuO, and < 0.01 % others. The RP (Ø < 0.5 cm) was ball-milled for 20 minutes producing PR-powder with the median diameter (D_{50}) $\leq$ 22 µm, and it contained a total of 16.8 % P_2O_5. The OM was the composted cattle wastes, screened to pass the 1-mm stainless steel screen. Urea and $CaCO_3$ respectively contained 44.2 % N and 38 % CaO. The liquid-foliar fertilizer (Orrin) contained of 4.04 % N, 3.22 % P_2O_5, 3.36 % K_2O, 0.32 % Ca, 0.40 % Mg, 0.12 % S, and 40, 122, 260, 10, 3, 0.1, and 1.2 $mg.L^{-}$ respectively of Fe, Mn, Zn, Cu, B, Co, and Mo.

2.2. Seed Coating Process

The seeds were coated using a rotating drum (350-L plastic drum), rotated with a 0.5-HP power machine at the speed of about 30 rpm. For coating the seeds of rice, 250-g seeds were coated with 2,500 g of the mixture of coating materials described above. In the first step, half of the mixed coating materials (SFRs + PRs + OM) were applied step-by-step onto the seed surface in the rotating drum, followed by spraying fresh water onto the seeds, forming the capsule-like coated seeds. Next, the other half of the coating materials were applied in the same way but using the binding substance of the urea + Orrin solution. The coated seeds were dried with a hairdryer (< 40^{o} C) in the rotating drum to avoid cracking of the coated seeds. Finally, the coated seeds were taken out from the drum, dried completely under sunray, and stored in a plastic container. The coating procedure for the seeds of groundnut was the same as that for rice seeds, but the coating material was the mixture of SRFs + PRs + OM + $CaCO_3$, and the binding material was Orrin applied in the second step of the seed coating process.

Due to the size variability of seeds within and between crop varieties, the coating processes produced various sizes and weight ratios of the seed to the coating material. Thus, the coated seeds were grouped into three size categories, i.e., small (SS), medium (MS), and big (BS) coated seeds for each variety, and the corresponding weight ratio (see Table 1).

Table 1. The size category and the weight ratio of seed to coating material

The size categories of coated seeds	Rice		Groundnut	
	Impari 32	BSM	Lombok	Kelinci
Small (SS)	1:10	1:8	1:4	1:6
Medium (MS)	1:20	1:15	1:6	1:9
Big (BS)	1:30	1:20	1:8	1:12

2.3. Experimental Setting

Four sets of experiments were prepared in a glasshouse; two sets were for testing the coated seeds of two varieties rice (Impari 32 and BSM varieties), and the other two sets were for testing the coated seeds of two varieties of groundnut (Lombok and Kelinci varieties). A completely randomized experimental design was laid out for each set of experiments with a treatment consisting of uncoated seed (NC), small (SS), medium (MS), and big (BS) sizes of coated seeds, and those were triplicated. Nitrogen and phosphate fertilizers (2.0 $g.pot^{-}$ of N and 0.4.pot^{-} of P_2O_5) were applied to the NC of rice; and phosphate fertilizer (0.4 $g.pot^{-}$ of P_2O_5) was applied to the NC of groundnut.

The soil used in this experiment was the 20-cm top of Ustipsamments of Akar-Akar, Northern Lombok, Indonesia, developed from pumice stones. The soil was air-dried and screened to pass a 2-mm stainless steel screen. The characteristics of the soil were sandy textured (4.2 % clay, 23.3 % silt, 74.5 % sand), neutral (pH_{H2O} 7.4), low N-total (0.02 % N),

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low phosphate (116 mg.kg^{-} of P by Bray-II), low organic matter (1.9 % total C), low CEC (4.8 cmol.kg^{-}), lack of exchangeable cations (0.69, 0.22, 1.6, and 1.5 cmol.kg^{-} of K, Na, Ca, and Mg, respectively) and extractable micronutrients (7.4, 1.2, and 1.3 mg.kg^{-} of Fe, Cu, and Zn, respectively).

Planting rice: each pot was filled with 10-kg soil, saturated with deionized water (2 L.pot^{-}), mudded, and allowed to equilibrate overnight. Three seeds of rice were planted in each pot accordingly to the treatment at about 0.5-cm depth. After the young plants grew about 5-cm height, the water level in each pot was maintained at 1.5 – 5 cm accordingly to the growing stage of the plant. Rice was harvested at 105 days after planting.

Planting groundnut: each pot was filled with 6-kg soil, moistened with deionized water to about field capacity (120 mL.pot^{-}), and allowed to equilibrate overnight. One seed was planted in each pot, accordingly to the treatment, at about 0.5-cm depth. Soil moisture was maintained to about field capacity. Groundnut was harvested at 95 days after planting.

2.4. Statistical Analyses

The main collected data (parameters) were the germinating period of seeds and several components of growth and yield for each plant. The analyses of variance (ANOVA) were carried out, and the tests of the least significant difference (LSD) at $\alpha = 0.05$ were applied to the appropriate sets of data (significantly different based on the ANOVA).

3. RESULTS AND DISCUSSION

3.1. The Growth and Yield of Rice

Statistically, the seed coating with organomineral fertilizer significantly increased the days required by the coated seeds to germinate, reduced the growth and yield components of both rice varieties (Table 2). It was also noticeable (data were not shown) that the plants of the coated seeds were most probably deficient of N, indicated by the yellowish-green of most leaves, starting in the third weeks after planting.

As shown in Table 2, the non-coated seeds (NC) germinated in six to seven days, while the coated seeds were in about teen to thirteen days after planting; and the bigger the size, the more days required by the coated seeds to germinate. Inversely, for each rice variety, the bigger the size of coated seeds, the lower the number of tellers and the weights of biomass and grain yield.

The delay of germination for the coated seeds was most probably due to the coated seeds required extra time for cracking the coating materials surrounding the seed surface. Our visual observation indicated that in the water-saturated or mudded soil, the coating materials on the surface of rice seeds started to crack in one to three days after planting.

3.2. The Growth and Yield of Groundnut

The effects of the seed coating with organomineral fertilizer on the growth and yield components of groundnut are presented in Table 3. The seed coating depressed the germination of both varieties of groundnut, and the larger the coating size, the more time required by groundnut seeds to germinate. Inversely, the coating treatment tended to decrease the other growth and yield components.

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As shown in Table 3, the uncoated seeds (NC) of groundnut germinated in 7 - 8 days, whereas the coated seeds germinated in 13 – 23 days after planting, and the ticker (bigger) the coated seeds, the more time required by the coated seeds to germinate.

Table 2. The effects of seed coating on the growth and yield components of rice

Variety and Parameter	Seed Treatment*			
	NC	SS	MS	BS
Impari 32:				
a. Germination (days)	6.3a	10.0b	11.3b	11.7b
b. Number of tellers (.pot^{-})	15.0b	17.3b	10.7a	11.0a
c. Dry biomass (g.pot^{-})	29.94c	29.12c	15.71b	6.77a
d. Dry grains (g.pot^{-})	39.07c	39.27c	34.93b	29.77a
Bunda Sri Madrin (BSM):				
a. Germination (days)	7.0a	10.3b	11.0b	12.7c
b. Number of tellers (.pot^{-})	18.7c	13.7b	11.0a	9.3a
c. Dry biomass (g.pot^{-})	25.43c	16.54ab	19.90b	15.16a
d. Dry grains (g.pot^{-})	37.57b	35.87b	31.50a	29.17a

* NC, SS, MS, and BS respectively are the non-coated seeds, small coated seeds, medium coated seeds, and big coated seeds. The numbers in the same raw, followed by the same letters indicate not significantly different based on its critical value of the $LSD_{\alpha=0.05}$ for each parameter.

Table 3. The effects of seed coating on the growth and yield components of groundnut

Variety and Parameter	Seed Treatment*			
	NC	SS	MS	BS
Lombok:				
Germination (days)	7.7a	13.3a	14.7bc	17.7c
Biomass (g.pot-)	27.20b	17.47a	20.17a	18.53a
Number of pods (.pot^{-})	18.3	16.0	18.0	14.7
Dry pods (g.pot^{-})	16.00b	18.10b	18.30b	11.67a
Dry seeds (g.pot^{-})	12.60ab	15.43b	13.10ab	9.30a
Kelinci:				
Germination (days)	7.3a	16.3b	18.7bc	22.3d
Biomass (g.pot^{-})	26.67b	21.03a	21.03a	18.53a
Number of pods (.pot^{-})	11.7a	13.0a	13.0a	9.0a
Dry pods (g.pot^{-})	13.33b	13.10b	13.10b	9.33a
Dry seeds (g.pot^{-})	9.23a	10.07ab	10.07ab	6.97a

* NC, SS, MS, and BS respectively are the non-coated seeds, small coated seeds, medium coated seeds, and big coated seeds. The numbers in the same raw followed by the same letters indicate not significantly different based on its critical value of the $LSD_{\alpha=0.05}$ for each parameter.

There were different responses between the two varieties of groundnut to the seed coating treatment. For Lombok variety, the seed coating did not affect the number of pods but increased the weights of dry pods and seeds of SC and MS. For Kelinci variety, the seed treatment quadratically increased all of those components, and the maximum values were reached by the medium size of coated seeds (MC). These results suggested that the most appropriate weight ratios for the coated seeds of groundnut could be 1:6 to 1:9, or was 1:7.5 on average.

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3.3. General Discussion

This research was the first attempt to find out an appropriate method of seed coating for food crops with organomineral fertilizer. So, knowing the causes of unsatisfied results of the coating was very important, enabling us to fix the seed coating method with organomineral fertilizer. Base on available data from this research, however, it was too difficult, if not impossible, to provide simple explanation about the primary causes of the decreases of growths and yields of both crops grown from the coated seeds.

The most noticeable cause was that the coated seeds required extra time for cracking the coating material before the seeds can germinate. Specific for the coated seeds of rice, an additional cause of decreasing the growth and grain yield was N-deficiency. However, those facts were most probably not the primary causes of decreasing the growth and yield of both crops.

The coating materials contained a high concentration of plant-essential nutrients, and most of those nutrients were in the soluble forms, especially urea and Orrin. This condition has brought to the thought that the coated seeds maybe toxified by the high concentration of nutrients dissolved from the coating materials. In this research, anticipation was made to avoid direct contact of the soluble nutrients with the seeds being coated, which was by applying urea or/and Orrin at the latest step in the application of the coating materials onto the seeds. But that effort seemed to be insufficient to avoid the toxifying the seeds by over-concentration of nutrients from the coating materials. Thus, the seed coating method described in this research needed some modification, especially for the composition of seed coating or/and binding materials, and the procedure of applying the coating materials onto the seed surface.

4. CONCLUSION AND RECOMMENDATION

The seed coating with the organomineral fertilizer consisting mainly of silicate rock fertilizer, rock phosphate, and organic matter delayed the seedling and decreased most of the growth and yield components of rice and groundnut. The seed coating method described in this research needed some modifications, of which especially were the composition of the coating or/and binding materials, and the procedure of applying the coating materials onto the seed surface.

ACKNOWLEDGEMENTS

We thank the Directorate General of Higher Education, The Ministry of Research, Technology, and Higher Education, The Republic of Indonesia, for its financial support for the research project.

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AUTHORS' CONTRIBUTIONS

Author JP designed the study, technical aspects of seed coating, construct the outline and wrote the first draft of the manuscripts. Author AAKS performed the statistical analysis, managed the literature searches for seed treatments. All authors read and approved the final manuscript.

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Seed Coating with Organomineral Fertilizer, An Alternative Method to Improve the Efficiency of Farming

ABSTRACT

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1. INTRODUCTION

Seed and fertilizer are two vital inputs in the farming of crops grown from seed, such as rice (*Oryza sativa* L.) and groundnut (*Arachis hypogaea* L.). The current issue of farming technology relating to the seeds is seed coating, and of that for fertilizer is the utilization of the natural sources of plant nutrients, including silicate rocks. Combining those farming inputs into a unit material, which is coating the seeds with the fertilizer, may be an appropriate method to improve the productivity and profitability of the farming.

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2. MATERIAL AND

2.1. Seeds and Coating Materials

The seeds of two varieties of rice, i.e., Impari 32 and Bunda Sri Madrin (BSM), and two varieties of groundnut, i.e., Lombok and Kelinci, were prepared. The coating materials for rice seeds were SRF (87.5 % w/w), PR (4 % w/w), urea (4 % w/w), OM (2 % w/w), and liquid-foliar fertilizer (trademarked as Orrin) (2.5 % v/w). The SRF, PR, and OM were mixed, while urea was dissolved into Orrin that was functioned as the binding substance. The coating materials for groundnut seeds were the same as those for rice seeds, but the urea was substituted with $CaCO_3$ (4 % w/w) added to the mixture of SRFs + PRs + OM, and the binding substance for the coated seeds was only Orrin.

The SRF was the finely ground basaltic rocks from Rinjani Mt. in Lombok Island – Indonesia. The rocks were mechanically broken to Ø < 1 cm and then ball-milled for 40 minutes producing the SRF-powder with the median diameter (D_{50}) $\leq$ 5.4 μm. The chemical composition of the SRF-powder was 52.28 % SiO_2, 24.12 % Al_2O_3, 4.82 % CaO, 1.83 % 4.28 % K_2O, 2.30 % Na_2O, 6.24 % FeO, 0.15 MnO, 0.01 % ZnO, 0.30 % CuO, and < 0.01 %

others. The RP (Ø < 0.5 cm) was ball-milled for 20 minutes producing PR-powder with the median diameter (D_{50}) $\leq$ 22 µm, and it contained a total of 16.8 % P_2O_5. The OM was the composted cattle wastes, screened to pass the 1-mm stainless steel screen. Urea and $CaCO_3$ respectively contained 44.2 % N and 38 % CaO. The liquid-foliar fertilizer (Orrin) contained of 4.04 % N, 3.22 % P_2O_5, 3.36 % K_2O, 0.32 % Ca, 0.40 % Mg, 0.12 % S, and 40, 122, 260, 10, 3, 0.1, and 1.2 mg.L^{-} respectively of Fe, Mn, Zn, Cu, B, Co, and Mo.

2.2. Seed Coating Process

The seeds were coated using a rotating drum (350-L plastic drum), rotated with a 0.5-HP power machine at the speed of about 30 rpm. For coating the seeds of rice, 250-g seeds were coated with 2,500 g of the mixture of coating materials described above. In the first step, half of the mixed coating materials (SFRs + PRs + OM) were applied step-by-step onto the seed surface in the rotating drum, followed by spraying fresh water onto the seeds, forming the capsule-like coated seeds. Next, the other half of the coating materials were applied in the same way but using the binding substance of the urea + Orrin solution. The coated seeds were dried with a hairdryer (< 40^{o} C) in the rotating drum to avoid cracking of the coated seeds. Finally, the coated seeds were taken out from the drum, dried completely under sunray, and stored in a plastic container. The coating procedure for the seeds of groundnut was the same as that for rice seeds, but the coating material was the mixture of SRFs + PRs + OM + $CaCO_3$, and the binding material was Orrin applied in the second step of the seed coating process.

Due to the size variability of seeds within and between crop varieties, the coating processes produced various sizes and weight ratios of the seed to the coating material. Thus, the coated seeds were grouped into three size categories, i.e., small (SS), medium (MS), and big (BS) coated seeds for each variety, and the corresponding weight ratio (see Table 1).

Table 1. The size category and the weight ratio of seed to coating material

The size categories of coated seeds	Rice		Groundnut	
	Impari 32	BSM	Lombok	Kelinci
Small (SS)	1:10	1:8	1:4	1:6
Medium (MS)	1:20	1:15	1:6	1:9
Big (BS)	1:30	1:20	1:8	1:12

2.3. Experimental Setting

Four sets of experiments were prepared in a glasshouse; two sets were for testing the coated seeds of two varieties rice (Impari 32 and BSM varieties), and the other two sets were for testing the coated seeds of two varieties of groundnut (Lombok and Kelinci varieties). A completely randomized experimental design was laid out for each set of experiments with a treatment consisting of uncoated seed (NC), small (SS), medium (MS), and big (BS) sizes of coated seeds, and those were triplicated. Nitrogen and phosphate fertilizers (2.0 g.pot^{-} of N and 0.4.pot^{-} of P_2O_5) were applied to the NC of rice; and phosphate fertilizer (0.4 g.pot^{-} of P_2O_5) was applied to the NC of groundnut.

The soil used in this experiment was the 20-cm top of Ustipsamments of Akar-Akar, Northern Lombok, Indonesia, developed from pumice stones. The soil was air-dried and screened to pass a 2-mm stainless steel screen. The characteristics of the soil were sandy textured (4.2 % clay, 23.3 % silt, 74.5 % sand), neutral (pH_{H2O} 7.4), low N-total (0.02 % N), low phosphate (116 mg.kg^{-} of P by Bray-II), low organic matter (1.9 % total C), low CEC (4.8

cmol.kg^{-}), lack of exchangeable cations (0.69, 0.22, 1.6, and 1.5 cmol.kg^{-} of K, Na, Ca, and Mg, respectively) and extractable micronutrients (7.4, 1.2, and 1.3 mg.kg^{-} of Fe, Cu, and Zn, respectively).

Planting rice: each pot was filled with 10-kg soil, saturated with deionized water (2 L.pot^{-}), mudded, and allowed to equilibrate overnight. Three seeds of rice were planted in each pot accordingly to the treatment at about 0.5-cm depth. After the young plants grew about 5-cm height, the water level in each pot was maintained at 1.5 – 5 cm accordingly to the growing stage of the plant. Rice was harvested at 105 days after planting.

Planting groundnut: each pot was filled with 6-kg soil, moistened with deionized water to about field capacity (120 mL.pot^{-}), and allowed to equilibrate overnight. One seed was planted in each pot, accordingly to the treatment, at about 0.5-cm depth. Soil moisture was maintained to about field capacity. Groundnut was harvested at 95 days after planting.

2.4. Statistical Analyses

The main collected data (parameters) were the germinating period of seeds and several components of growth and yield for each plant. The analyses of variance (ANOVA) were carried out, and the tests of the least significant difference (LSD) at $\alpha = 0.05$ were applied to the appropriate sets of data (significantly different based on the ANOVA).

3. RESULTS AND DISCUSSION

3.1. The Growth and Yield of Rice

Statistically, the seed coating with organomineral fertilizer significantly increased the days required by the coated seeds to germinate, reduced the growth and yield components of both rice varieties (Table 2). It was also noticeable (data were not shown) that the plants of the coated seeds were most probably deficient of N, indicated by the yellowish-green of most leaves, starting in the third weeks after planting.

As shown in Table 2, the non-coated seeds (NC) germinated in six to seven days, while the coated seeds were in about teen to thirteen days after planting; and the bigger the size, the more days required by the coated seeds to germinate. Inversely, for each rice variety, the bigger the size of coated seeds, the lower the number of tellers and the weights of biomass and grain yield.

The delay of germination for the coated seeds was most probably due to the coated seeds required extra time for cracking the coating materials surrounding the seed surface. Our visual observation indicated that in the water-saturated or mudded soil, the coating materials on the surface of rice seeds started to crack in one to three days after planting.

3.2. The Growth and Yield of Groundnut

The effects of the seed coating with organomineral fertilizer on the growth and yield components of groundnut are presented in Table 3. The seed coating depressed the germination of both varieties of groundnut, and the larger the coating size, the more time required by groundnut seeds to germinate. Inversely, the coating treatment tended to decrease the other growth and yield components.

As shown in Table 3, the uncoated seeds (NC) of groundnut germinated in 7 - 8 days, whereas the coated seeds germinated in 13 – 23 days after planting, and the ticker (bigger) the coated seeds, the more time required by the coated seeds to germinate.

Table 2. The effects of seed coating on the growth and yield components of rice

Variety and Parameter	Seed Treatment*			
	NC	SS	MS	BS
Impari 32:				
a. Germination (days)	6.3a	10.0b	11.3b	11.7b
b. Number of tellers (.pot^{-})	15.0b	17.3b	10.7a	11.0a
c. Dry biomass (g.pot^{-})	29.94c	29.12c	15.71b	6.77a
d. Dry grains (g.pot^{-})	39.07c	39.27c	34.93b	29.77a
Bunda Sri Madrin (BSM):				
a. Germination (days)	7.0a	10.3b	11.0b	12.7c
b. Number of tellers (.pot^{-})	18.7c	13.7b	11.0a	9.3a
c. Dry biomass (g.pot^{-})	25.43c	16.54ab	19.90b	15.16a
d. Dry grains (g.pot^{-})	37.57b	35.87b	31.50a	29.17a

* NC, SS, MS, and BS respectively are the non-coated seeds, small coated seeds, medium coated seeds, and big coated seeds. The numbers in the same raw, followed by the same letters indicate not significantly different based on its critical value of the $LSD_{\alpha=0.05}$ for each parameter.

Table 3. The effects of seed coating on the growth and yield components of groundnut

Variety and Parameter	Seed Treatment*			
	NC	SS	MS	BS
Lombok:				
Germination (days)	7.7a	13.3a	14.7bc	17.7c
Biomass (g.pot-)	27.20b	17.47a	20.17a	18.53a
Number of pods (.pot^{-})	18.3	16.0	18.0	14.7
Dry pods (g.pot^{-})	16.00b	18.10b	18.30b	11.67a
Dry seeds (g.pot^{-})	12.60ab	15.43b	13.10ab	9.30a
Kelinci:				
Germination (days)	7.3a	16.3b	18.7bc	22.3d
Biomass (g.pot^{-})	26.67b	21.03a	21.03a	18.53a
Number of pods (.pot^{-})	11.7a	13.0a	13.0a	9.0a
Dry pods (g.pot^{-})	13.33b	13.10b	13.10b	9.33a
Dry seeds (g.pot^{-})	9.23a	10.07ab	10.07ab	6.97a

* NC, SS, MS, and BS respectively are the non-coated seeds, small coated seeds, medium coated seeds, and big coated seeds. The numbers in the same raw followed by the same letters indicate not significantly different based on its critical value of the $LSD_{\alpha=0.05}$ for each parameter.

There were different responses between the two varieties of groundnut to the seed coating treatment. For Lombok variety, the seed coating did not affect the number of pods but increased the weights of dry pods and seeds of SC and MS. For Kelinci variety, the seed treatment quadratically increased all of those components, and the maximum values were reached by the medium size of coated seeds (MC). These results suggested that the most appropriate weight ratios for the coated seeds of groundnut could be 1:6 to 1:9, or was 1:7.5 on average.

3.3. General Discussion

This research was the first attempt to find out an appropriate method of seed coating for food crops with organomineral fertilizer. So, knowing the causes of unsatisfied results of the coating was very important, enabling us to fix the seed coating method with organomineral fertilizer. Base on available data from this research, however, it was too difficult, if not impossible, to provide simple explanation about the primary causes of the decreases of growths and yields of both crops grown from the coated seeds.

The most noticeable cause was that the coated seeds required extra time for cracking the coating material before the seeds can germinate. Specific for the coated seeds of rice, an additional cause of decreasing the growth and grain yield was N-deficiency. However, those facts were most probably not the primary causes of decreasing the growth and yield of both crops.

The coating materials contained a high concentration of plant-essential nutrients, and most of those nutrients were in the soluble forms, especially urea and Orrin. This condition has brought to the thought that the coated seeds maybe toxified by the high concentration of nutrients dissolved from the coating materials. In this research, anticipation was made to avoid direct contact of the soluble nutrients with the seeds being coated, which was by applying urea or/and Orrin at the latest step in the application of the coating materials onto the seeds. But that effort seemed to be insufficient to avoid the toxifying the seeds by over-concentration of nutrients from the coating materials. Thus, the seed coating method described in this research needed some modification, especially for the composition of seed coating or/and binding materials, and the procedure of applying the coating materials onto the seed surface.

4. CONCLUSION AND RECOMMENDATION

The seed coating with the organomineral fertilizer consisting mainly of silicate rock fertilizer, rock phosphate, and organic matter delayed the seedling and decreased most of the growth and yield components of rice and groundnut. The seed coating method described in this research needed some modifications, of which especially were the composition of the coating or/and binding materials, and the procedure of applying the coating materials onto the seed surface.

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Original Research Article

Seed Coating with Organomineral Fertilizer, An Alternative Method to Improve the Efficiency of Farming

ABSTRACT

Seed and fertilizer are two important farming inputs, which are commonly available and used separately. Combining both materials into a unit of fertilizer-coated seed may improve farming efficiency. Technically, however, the appropriate seed coating method must be found out, and this research was the first effort of finding the method. A glasshouse experiment was carried out to identify the growth and yield of the coated seeds of rice and groundnut with organomineral fertilizer in three different sizes (i.e., small (SS), medium (MS), and big sizes (BS). Four sets of experiments were prepared, two of those were for testing two varieties of rice, and the others were for testing two varieties of groundnut. Each experiment was laid out in a complete randomized design; the treatment was the size of coated seeds (SS, MS, BS, and a control - uncoated seeds) in triplicates. Results reveal that the seed coating delayed the germination of rice seeds for 2 – 3 days and groundnut seeds for 7 – 16 days. The coating also suppressed the growth and yield of rice but improved the growth and yield of groundnut. The coated seeds of groundnut producing the higher yield were the small and medium sizes (the weight ratios of seed :coating material were 1:4 and 1:9). In case of rice seeds, the reduces of growth and yield of the coated seeds were most probably due to the direct contact of the high concentration of nutrients, especially nitrogen, dissolved from the coating material with the seeds. In conclusion, the seed coating with organomineral fertilizer improve the yield of groundnut, and the best coating was in small to medium sizes. Especially for coating the rice seeds, further efforts were needed to fix the composition of organomineral fertilizer, especially the type N substances used, and the steps of applying the materials onto the seeds.

Keywords: organomineral fertilizer, coating materials, seed coating, silicate rock fertilizer

1. INTRODUCTION

Seed and fertilizer are two vital inputs in the farming of crops grown from seed, such as rice (*Oryza sativa* L.) and groundnut (*Arachis hypogaea* L.). The current issue of farming technology relating to the seeds is seed coating, and of that for fertilizer is the utilization of the natural sources of plant nutrients, including silicate rocks. Combining those farming inputs into a unit material, which is coating the seeds with the fertilizer, may be an appropriate method to improve the productivity and profitability of the farming.

Seed coating is an important technology that has been applied by seed industries for decades. The industries use various coating materials, and the most common one is pesticides [1]. The main aims of using pesticides are to suppress, control, or repel the soil-borne pathogens, insects, and other pests attacking seeds, seedlings, or plants [2, 3].

However, exposing pesticides into farming land may potentially develop pest resistance and create various negative-ecological effects [4]. Thus, it is a challenge for the seed industries to find out and use the more environmentally sound coating materials.

Fertilizer is another important farming input, used to fulfill the optimum requirement of crops for essential nutrients. The appropriate fertilizer application, referring to the ideal concept of proportional fertilization, however, is often difficult to be applied on the farm level, especially by small farmers in developing countries, due to technical or/and economic constraints. The high variability of soil properties, for example, may cause the difficulties to define the appropriate rate of fertilizer application; and the lack of farming capital often limits the small farmers to access the appropriate quantities of synthetic fertilizers. Responding to the cases, many researchers [5, 6, 7, 8] proposed the utilization of natural sources of plant-nutrients, e.g., silicate rocks, as cheap and environmentally sound fertilizer. However, the use of silicate rock fertilizers (SRFs) was limited in farming practices due to the very slow release of nutrients from the SRFs. Consequently, the farming required very high doses (> 20 $t.ha^{-1}$) of SRFs [7]. However, by employing ball milling in producing SRFs [9, 10], or/and mixing SRFs with organic matter (organomineral fertilizer), significantly improved the effectiveness of SRFs [11].

The limitations of the seed coating and fertilizer application described above inspired us to propose combining the seed with organomineral fertilizer into the organomineral-coated seeds as an alternative solution for the farming constraints. The organomineral fertilizer consisted mainly of SRFs, phosphatic rocks (PRs), and organic matters (OM), and those materials were coated onto the seeds and intended to sufficiently fulfill the optimum requirement of essential nutrients for the without additional fertilizers. Planting the organomineral-coated seeds maybe also reduce the farming cost with less negative-environmental effects, and improve soil quality due to the residual effects of the coating materials (organomineral fertilizer) remaining in the soil.

This research was the first attempt to evaluate if the proposed farming method described above was realistic. The main objective of this research was to identify the effects of seed coating with organomineral fertilizer on the growth and yield components of rice (*Oryza sativa* L) and groundnut (*Arachis hypogaea* L).

2. MATERIAL AND

2.1. Seeds and Coating Materials

The seeds of two varieties of rice, i.e., Impari 32 and Bunda Sri Madrin (BSM), and two varieties of groundnut, i.e., Lombok and Kelinci, were prepared. The coating materials for rice seeds were SRF (87.5 % w/w), PR (4 % w/w), urea (4 % w/w), OM (2 % w/w), and liquid-foliar fertilizer (trademarked as Orrin) (2.5 % v/w). The SRF, PR, and OM were mixed, while urea was dissolved into Orrin that was functioned as the binding substance. The coating materials for groundnut seeds were the same as those for rice seeds, but the urea was substituted with $CaCO_3$ (4 % w/w) added to the mixture of SRFs + PRs + OM, and the binding substance for the coated seeds was only Orrin.

The SRF was the finely ground basaltic rocks from Rinjani Mt. in Lombok Island – Indonesia. The rocks were mechanically broken to Ø < 1 cm and then ball-milled for 40 minutes producing the SRF-powder with the median diameter (D_{50}) $\leq$ 5.4 µm. The chemical composition of the SRF-powder was 52.28 % SiO_2, 24.12 % Al_2O_3, 4.82 % CaO, 1.83 % 4.28 % K_2O, 2.30 % Na_2O, 6.24 % FeO, 0.15 MnO, 0.01 % ZnO, 0.30 % CuO, and < 0.01 %

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The seeds were coated using a rotating drum (350-L plastic drum), rotated with a 0.5-HP power machine at the speed of about 30 rpm. For coating the seeds of rice, 250-g seeds were coated with 2,500 g of the mixture of coating materials described above. In the first step, half of the mixed coating materials (SFRs + PRs + OM) were applied step-by-step onto the seed surface in the rotating drum, followed by spraying fresh water onto the seeds, forming the capsule-like coated seeds. Next, the other half of the coating materials were applied in the same way but using the binding substance of the urea + Orrin solution. The coated seeds were dried with a hairdryer (< 40^o C) in the rotating drum to avoid cracking of the coated seeds. Finally, the coated seeds were taken out from the drum, dried completely under sunray, and stored in a plastic container. The coating procedure for the seeds of groundnut was the same as that for rice seeds, but the coating material was the mixture of SRFs + PRs + OM + $CaCO_3$, and the binding material was Orrin applied in the second step of the seed coating process.

Due to the size variability of seeds within and between crop varieties, the coating processes produced various sizes and weight ratios of the seed to the coating material. Thus, the coated seeds were grouped into three size categories, i.e., small (SS), medium (MS), and big (BS) coated seeds for each variety, and the corresponding weight ratio (see Table 1).

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Planting rice: each pot was filled with 10-kg soil, saturated with deionized water (2 L.pot^{-}), mudded, and allowed to equilibrate overnight. Three seeds of rice were planted in each pot accordingly to the treatment at about 0.5-cm depth. After the young plants grew about 5-cm height, the water level in each pot was maintained at 1.5 – 5 cm accordingly to the growing stage of the plant. Rice was harvested at 105 days after planting sowing.

Planting Sowing groundnut: each pot was filled with 6-kg soil, moistened with deionized water to about field capacity (120 mL.pot^{-}), and allowed to equilibrate overnight. One seed was planted in each pot, accordingly to the treatment, at about 0.5-cm depth. Soil moisture was maintained to about field capacity. Groundnut was harvested at 95 days after planting.

2.4. Statistical Analyses

The main collected data (parameters) were the germinating period of seeds and several components of growth and yield for each plant list the components of growth and yield.. The analyses of variance (ANOVA) were carried out, and the tests of the least significant difference (LSD) at α = 0.05 were applied to the appropriate sets of data (significantly different based on the ANOVA).

3. RESULTS AND DISCUSSION

3.1. The Growth and Yield of Rice

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The delay of germination for the coated seeds was most probably due to the coated seeds required extra time for cracking the coating materials surrounding the seed surface. Our visual observation indicated that in the water-saturated or mudded soil, the coating materials on the surface of rice seeds started to crack in one to three days after planting.

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The effects of the seed coating with organomineral fertilizer on the growth and yield components of groundnut are presented in Table 3. The seed coating depressed the germination of both varieties of groundnut, and the larger the coating size, the more time required by groundnut seeds to germinate. Inversely, the coating treatment tended to decrease the other growth and yield components.

As shown in Table 3, the uncoated seeds (NC) of groundnut germinated in 7 - 8 days, whereas the coated seeds germinated in 13 – 23 days after planting, and the ticker (bigger) the coated seeds, the more time required by the coated seeds to germinate.

Table 2. The effects of seed coating on the growth and yield components of rice

Variety and Parameter	Seed Treatment*			
	NC	SS	MS	BS
Impari 32:				
a. Germination (days)	6.3a	10.0b	11.3b	11.7b
b. Number of tellers (.pot^{-})	15.0b	17.3b	10.7a	11.0a
c. Dry biomass (g.pot^{-})	29.94c	29.12c	15.71b	6.77a
d. Dry grains (g.pot^{-})	39.07c	39.27c	34.93b	29.77a
Bunda Sri Madrin (BSM):				
a. Germination (days)	7.0a	10.3b	11.0b	12.7c
b. Number of tellers (.pot^{-})	18.7c	13.7b	11.0a	9.3a
c. Dry biomass (g.pot^{-})	25.43c	16.54ab	19.90b	15.16a
d. Dry grains (g.pot^{-})	37.57b	35.87b	31.50a	29.17a

* NC, SS, MS, and BS respectively are the non-coated seeds, small coated seeds, medium coated seeds, and big coated seeds. The numbers in the same raw, followed by the same letters indicate not significantly different based on its critical value of the $LSD_{\alpha=0.05}$ for each parameter.

Table 3. The effects of seed coating on the growth and yield components of groundnut

Variety and Parameter	Seed Treatment*			
	NC	SS	MS	BS
Lombok:				
Germination (days)	7.7a	13.3a	14.7bc	17.7c
Biomass (g.pot-)	27.20b	17.47a	20.17a	18.53a
Number of pods (.pot^{-})	18.3	16.0	18.0	14.7
Dry pods (g.pot^{-})	16.00b	18.10b	18.30b	11.67a
Dry seeds (g.pot^{-})	12.60ab	15.43b	13.10ab	9.30a
Kelinci:				
Germination (days)	7.3a	16.3b	18.7bc	22.3d
Biomass (g.pot^{-})	26.67b	21.03a	21.03a	18.53a
Number of pods (.pot^{-})	11.7a	13.0a	13.0a	9.0a
Dry pods (g.pot^{-})	13.33b	13.10b	13.10b	9.33a
Dry seeds (g.pot^{-})	9.23a	10.07ab	10.07ab	6.97a

* NC, SS, MS, and BS respectively are the non-coated seeds, small coated seeds, medium coated seeds, and big coated seeds. The numbers in the same raw followed by the same letters indicate not significantly different based on its critical value of the $LSD_{\alpha=0.05}$ for each parameter.

There were different responses between the two varieties of groundnut to the seed coating treatment. For Lombok variety, the seed coating did not affect the number of pods but increased the weights of dry pods and seeds of SC and MS. For Kelinci variety, the seed treatment quadratically increased all of those components, and the maximum values were reached by the medium size of coated seeds (MC). These results suggested that the most appropriate weight ratios for the coated seeds of groundnut could be 1:6 to 1:9, or was 1:7.5 on average.

3.3. General Discussion

This research was the first attempt to find out an appropriate method of seed coating for food crops with organomineral fertilizer. So, knowing the causes of unsatisfied results of the coating was very important, enabling us to fix the seed coating method with organomineral fertilizer. Base on available data from this research, however, it was too difficult, if not impossible, to provide simple explanation about the primary causes of the decreases of growths and yields of both crops grown from the coated seeds.

The most noticeable cause was that the coated seeds required extra time for cracking the coating material before the seeds can germinate. Specific for the coated seeds of rice, an additional cause of decreasing the growth and grain yield was N-deficiency. However, those facts were most probably not the primary causes of decreasing the growth and yield of both crops.

The coating materials contained a high concentration of plant-essential nutrients, and most of those nutrients were in the soluble forms, especially urea and Orrin. This condition has brought to the thought that the coated seeds maybe toxified by the high concentration of nutrients dissolved from the coating materials. In this research, anticipation was made to avoid direct contact of the soluble nutrients with the seeds being coated, which was by applying urea or/and Orrin at the latest step in the application of the coating materials onto the seeds. But that effort seemed to be insufficient to avoid the toxifying the seeds by over-concentration of nutrients from the coating materials. Thus, the seed coating method described in this research needed some modification, especially for the composition of seed coating or/and binding materials, and the procedure of applying the coating materials onto the seed surface.

4. CONCLUSION AND RECOMMENDATION

The seed coating with the organomineral fertilizer consisting mainly of silicate rock fertilizer, rock phosphate, and organic matter delayed the seedling and decreased most of the growth and yield components of rice and groundnut. The seed coating method described in this research needed some modifications, of which especially were the composition of the coating or/and binding materials, and the procedure of applying the coating materials onto the seed surface.

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SDI Review Form 1.6

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PART 1: **Review Comments**

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Compulsory REVISION comments	This work tried new approaches for reducing fertilizer amount used and, consequently, the associated cost. Although it is an interesting idea, the excessive amount of fertilizer probably explain the poor results. Nonetheless, the paper deserves to be published due to the developed method. Some suggestions are presented bellow.	
Minor REVISION comments	Please, review the phrase: "those materials were coated onto the seeds and intended to sufficiently fulfill the optimum requirement of essential nutrients for the without additional fertilizers" The composition on the sentence "The chemical composition of the SRF-powder was 52.28 % SiO_2, 24.12 % Al_2O_3, 4.82 % CaO, 1.83 % 4.28 % K_2O, 2.30 % Na_2O, 6.24 % FeO, 0.15 MnO, 0.01 % ZnO, 0.30 % CuO, and < 0.01 % others" raises only 93.33%. Suggestion: comment on the other possible substances. The sentence "The RP (Ø < 0.5 cm) was ball-milled for 20 minutes producing PR-powder with the median diameter (D_{50}) ≤ 22 µm, and it contained a total of 16.8 % P_2O_5". I believe it is PR (Ø < 0.5 cm) The phrase "low phosphate (116 mg.kg^{-} of P by Bray-II), low organic matter (1.9 % total C), low CEC …" – it is uncommon use acronym without quote the expression. Furthermore, I believe it was only compatibility problem of Word Program, but all superscript does not appear on my text. I advise to check upon. Moreover "increased the weights of dry pods and seeds of SC and MS. For Kelinci variety, the seed treatment quadratically increased all of those components, and the maximum values were reached by the medium size of coated seeds (MC)" – I believe it is SS and MS (as quoted on Table 3) Suggestion – "Table 1. The size category and the weight ratio of seed to coating material" comment about fertilizer amount (roughly 1:10). I think it is important to emphasize that.	
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Original Research Article

Seed Coating with Organomineral Fertilizer, An Alternative Method to Improve the Efficiency of Farming

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ABSTRACT

Seed and fertilizer are two important farming inputs, which are commonly available and used separately. Combining both materials into a unit of fertilizer-coated seed may improve farming efficiency. Technically, however, the appropriate seed coating method must be found out, and this research was the first effort of finding the method. A glasshouse experiment was carried out to identify the growth and yield of the coated seeds of rice and groundnut with organomineral fertilizer in three different sizes (i.e., small (SS), medium (MS), and big sizes (BS). Four sets of experiments were prepared, two of those were for testing two varieties of rice, and the others were for testing two varieties of groundnut. Each experiment was laid out in a complete randomized design; the treatment was the size of coated seeds (SS, MS, BS, and a control - uncoated seeds) in triplicates. Results reveal that the seed coating delayed the germination of rice seeds for 2 – 3 days and groundnut seeds for 7 – 16 days. The coating also suppressed the growth and yield of rice but improved the growth and yield of groundnut. The coated seeds of groundnut producing the higher yield were the small and medium sizes (the weight ratios of seed:coating material were 1:4 and 1:9). In case of rice seeds, the reduces of growth and yield of the coated seeds were most probably due to the direct contact of the high concentration of nutrients, especially nitrogen, dissolved from the coating material with the seeds. In conclusion, the seed coating with organomineral fertilizer improve the yield of groundnut, and the best coating was in small to medium sizes. Especially for coating the rice seeds, further efforts were needed to fix the composition of organomineral fertilizer, especially the type N substances used, and the steps of applying the materials onto the seeds.

Keywords: organomineral fertilizer, coating materials, seed coating, silicate rock fertilizer

1. INTRODUCTION

Seed and fertilizer are two vital inputs in the farming of crops grown from seed, such as rice (*Oryza sativa* L.) and groundnut (*Arachis hypogaea* L.). The current issue of farming technology relating to the seeds is seed coating, and of that for fertilizer is the utilization of the natural sources of plant nutrients, including silicate rocks. Combining those farming inputs into a unit material, which is coating the seeds with the fertilizer, may be an appropriate method to improve the productivity and profitability of the farming.

Seed coating is an important technology that has been applied by seed industries for decades. The industries use various coating materials, and the most common one is pesticides [1]. The main aims of using pesticides are to suppress, control, or repel the soil-borne pathogens, insects, and other pests attacking seeds, seedlings, or plants [2, 3].

However, exposing pesticides into farming land may potentially develop pest resistance and create various negative-ecological effects [4]. Thus, it is a challenge for the seed industries to find out and use the more environmentally sound coating materials.

Fertilizer is another important farming input, used to fulfill the optimum requirement of crops for essential nutrients. The appropriate fertilizer application, referring to the ideal concept of proportional fertilization, however, is often difficult to be applied on the farm level, especially by small farmers in developing countries, due to technical or/and economic constraints. The high variability of soil properties, for example, may cause the difficulties to define the appropriate rate of fertilizer application; and the lack of farming capital often limits the small farmers to access the appropriate quantities of synthetic fertilizers. Responding to the cases, many researchers [5, 6, 7, 8] proposed the utilization of natural sources of plant-nutrients, e.g., silicate rocks, as cheap and environmentally sound fertilizer. However, the use of silicate rock fertilizers (SRFs) was limited in farming practices due to the very slow release of nutrients from the SRFs. Consequently, the farming required very high doses (> 20 t.ha^{-}) of SRFs [7]. However, by employing ball milling in producing SRFs [9, 10], or/and mixing SRFs with organic matter (organomineral fertilizer), significantly improved the effectiveness of SRFs [11].

The limitations of the seed coating and fertilizer application described above inspired us to propose combining the seed with organomineral fertilizer into the organomineral-coated seeds as an alternative solution for the farming constraints. The organomineral fertilizer consisted mainly of SRFs, phosphatic rocks (PRs), and organic matters (OM), and those materials were coated onto the seeds and intended to sufficiently fulfill the optimum requirement of essential nutrients for the without additional fertilizers. Planting the organomineral-coated seeds maybe also reduce the farming cost with less negative-environmental effects, and improve soil quality due to the residual effects of the coating materials (organomineral fertilizer) remaining in the soil.

This research was the first attempt to evaluate if the proposed farming method described above was realistic. The main objective of this research was to identify the effects of seed coating with organomineral fertilizer on the growth and yield components of rice (*Oryza sativa* L) and groundnut (*Arachis hypogaea* L).

2. MATERIAL AND

2.1. Seeds and Coating Materials

The seeds of two varieties of rice, i.e., Impari 32 and Bunda Sri Madrin (BSM), and two varieties of groundnut, i.e., Lombok and Kelinci, were prepared. The coating materials for rice seeds were SRF (87.5 % w/w), PR (4 % w/w), urea (4 % w/w), OM (2 % w/w), and liquid-foliar fertilizer (trademarked as Orrin) (2.5 % v/w). The SRF, PR, and OM were mixed, while urea was dissolved into Orrin that was functioned as the binding substance. The coating materials for groundnut seeds were the same as those for rice seeds, but the urea was substituted with $CaCO_3$ (4 % w/w) added to the mixture of SRFs + PRs + OM, and the binding substance for the coated seeds was only Orrin.

The SRF was the finely ground basaltic rocks from Rinjani Mt. in Lombok Island – Indonesia. The rocks were mechanically broken to Ø < 1 cm and then ball-milled for 40 minutes producing the SRF-powder with the median diameter (D_{50}) $\leq$ 5.4 µm. The chemical composition of the SRF-powder was 52.28 % SiO_2, 24.12 % Al_2O_3, 4.82 % CaO, 1.83 % 4.28 % K_2O, 2.30 % Na_2O, 6.24 % FeO, 0.15 MnO, 0.01 % ZnO, 0.30 % CuO, and < 0.01 %

others. The RP (Ø < 0.5 cm) was ball-milled for 20 minutes producing PR-powder with the median diameter (D_{50}) ≤ 22 µm, and it contained a total of 16.8 % P_2O_5. The OM was the composted cattle wastes, screened to pass the 1-mm stainless steel screen. Urea and $CaCO_3$ respectively contained 44.2 % N and 38 % CaO. The liquid-foliar fertilizer (Orrin) contained of 4.04 % N, 3.22 % P_2O_5, 3.36 % K_2O, 0.32 % Ca, 0.40 % Mg, 0.12 % S, and 40, 122, 260, 10, 3, 0.1, and 1.2 mg.L^{-} respectively of Fe, Mn, Zn, Cu, B, Co, and Mo.

2.2. Seed Coating Process

The seeds were coated using a rotating drum (350-L plastic drum), rotated with a 0.5-HP power machine at the speed of about 30 rpm. For coating the seeds of rice, 250-g seeds were coated with 2,500 g of the mixture of coating materials described above. In the first step, half of the mixed coating materials (SFRs + PRs + OM) were applied step-by-step onto the seed surface in the rotating drum, followed by spraying fresh water onto the seeds, forming the capsule-like coated seeds. Next, the other half of the coating materials were applied in the same way but using the binding substance of the urea + Orrin solution. The coated seeds were dried with a hairdryer (< 40^{o} C) in the rotating drum to avoid cracking of the coated seeds. Finally, the coated seeds were taken out from the drum, dried completely under sunray, and stored in a plastic container. The coating procedure for the seeds of groundnut was the same as that for rice seeds, but the coating material was the mixture of SRFs + PRs + OM + $CaCO_3$, and the binding material was Orrin applied in the second step of the seed coating process.

Due to the size variability of seeds within and between crop varieties, the coating processes produced various sizes and weight ratios of the seed to the coating material. Thus, the coated seeds were grouped into three size categories, i.e., small (SS), medium (MS), and big (BS) coated seeds for each variety, and the corresponding weight ratio (see Table 1).

Table 1. The size category and the weight ratio of seed to coating material

The size categories of coated seeds	Rice		Groundnut	
	Impari 32	BSM	Lombok	Kelinci
Small (SS)	1:10	1:8	1:4	1:6
Medium (MS)	1:20	1:15	1:6	1:9
Big (BS)	1:30	1:20	1:8	1:12

2.3. Experimental Setting

Four sets of experiments were prepared in a glasshouse; two sets were for testing the coated seeds of two varieties rice (Impari 32 and BSM varieties), and the other two sets were for testing the coated seeds of two varieties of groundnut (Lombok and Kelinci varieties). A completely randomized experimental design was laid out for each set of experiments with a treatment consisting of uncoated seed (NC), small (SS), medium (MS), and big (BS) sizes of coated seeds, and those were triplicated. Nitrogen and phosphate fertilizers (2.0 g.pot^{-} of N and 0.4.pot^{-} of P_2O_5) were applied to the NC of rice; and phosphate fertilizer (0.4 g.pot^{-} of P_2O_5) was applied to the NC of groundnut.

The soil used in this experiment was the 20-cm top of Ustipsamments of Akar-Akar, Northern Lombok, Indonesia, developed from pumice stones. The soil was air-dried and screened to pass a 2-mm stainless steel screen. The characteristics of the soil were sandy textured (4.2 % clay, 23.3 % silt, 74.5 % sand), neutral (pH_{H2O} 7.4), low N-total (0.02 % N), low phosphate (116 mg.kg^{-} of P by Bray-II), low organic matter (1.9 % total C), low CEC (4.8

$cmol.kg^{-}$), lack of exchangeable cations (0.69, 0.22, 1.6, and 1.5 $cmol.kg^{-}$ of K, Na, Ca, and Mg, respectively) and extractable micronutrients (7.4, 1.2, and 1.3 $mg.kg^{-}$ of Fe, Cu, and Zn, respectively).

Planting rice: each pot was filled with 10-kg soil, saturated with deionized water (2 $L.pot^{-}$), mudded, and allowed to equilibrate overnight. Three seeds of rice were planted in each pot accordingly to the treatment at about 0.5-cm depth. After the young plants grew about 5-cm height, the water level in each pot was maintained at 1.5 – 5 cm accordingly to the growing stage of the plant. Rice was harvested at 105 days after planting.

Planting groundnut: each pot was filled with 6-kg soil, moistened with deionized water to about field capacity (120 $mL.pot^{-}$), and allowed to equilibrate overnight. One seed was planted in each pot, accordingly to the treatment, at about 0.5-cm depth. Soil moisture was maintained to about field capacity. Groundnut was harvested at 95 days after planting.

2.4. Statistical Analyses

The main collected data (parameters) were the germinating period of seeds and several components of growth and yield for each plant. The analyses of variance (ANOVA) were carried out, and the tests of the least significant difference (LSD) at α = 0.05 were applied to the appropriate sets of data (significantly different based on the ANOVA).

3. RESULTS AND DISCUSSION

3.1. The Growth and Yield of Rice

Statistically, the seed coating with organomineral fertilizer significantly increased the days required by the coated seeds to germinate, reduced the growth and yield components of both rice varieties (Table 2). It was also noticeable (data were not shown) that the plants of the coated seeds were most probably deficient of N, indicated by the yellowish-green of most leaves, starting in the third weeks after planting.

As shown in Table 2, the non-coated seeds (NC) germinated in six to seven days, while the coated seeds were in about teen to thirteen days after planting; and the bigger the size, the more days required by the coated seeds to germinate. Inversely, for each rice variety, the bigger the size of coated seeds, the lower the number of tellers and the weights of biomass and grain yield.

The delay of germination for the coated seeds was most probably due to the coated seeds required extra time for cracking the coating materials surrounding the seed surface. Our visual observation indicated that in the water-saturated or mudded soil, the coating materials on the surface of rice seeds started to crack in one to three days after planting.

3.2. The Growth and Yield of Groundnut

The effects of the seed coating with organomineral fertilizer on the growth and yield components of groundnut are presented in Table 3. The seed coating depressed the germination of both varieties of groundnut, and the larger the coating size, the more time required by groundnut seeds to germinate. Inversely, the coating treatment tended to decrease the other growth and yield components.

As shown in Table 3, the uncoated seeds (NC) of groundnut germinated in 7 - 8 days, whereas the coated seeds germinated in 13 – 23 days after planting, and the ticker (bigger) the coated seeds, the more time required by the coated seeds to germinate.

Table 2. The effects of seed coating on the growth and yield components of rice

Variety and Parameter	Seed Treatment*			
	NC	SS	MS	BS
Impari 32:				
a. Germination (days)	6.3a	10.0b	11.3b	11.7b
b. Number of tellers (.pot^{-})	15.0b	17.3b	10.7a	11.0a
c. Dry biomass (g.pot^{-})	29.94c	29.12c	15.71b	6.77a
d. Dry grains (g.pot^{-})	39.07c	39.27c	34.93b	29.77a
Bunda Sri Madrin (BSM):				
a. Germination (days)	7.0a	10.3b	11.0b	12.7c
b. Number of tellers (.pot^{-})	18.7c	13.7b	11.0a	9.3a
c. Dry biomass (g.pot^{-})	25.43c	16.54ab	19.90b	15.16a
d. Dry grains (g.pot^{-})	37.57b	35.87b	31.50a	29.17a

* NC, SS, MS, and BS respectively are the non-coated seeds, small coated seeds, medium coated seeds, and big coated seeds. The numbers in the same raw, followed by the same letters indicate not significantly different based on its critical value of the $LSD_{\alpha=0.05}$ for each parameter.

Table 3. The effects of seed coating on the growth and yield components of groundnut

Variety and Parameter	Seed Treatment*			
	NC	SS	MS	BS
Lombok:				
Germination (days)	7.7a	13.3a	14.7bc	17.7c
Biomass (g.pot-)	27.20b	17.47a	20.17a	18.53a
Number of pods (.pot^{-})	18.3	16.0	18.0	14.7
Dry pods (g.pot^{-})	16.00b	18.10b	18.30b	11.67a
Dry seeds (g.pot^{-})	12.60ab	15.43b	13.10ab	9.30a
Kelinci:				
Germination (days)	7.3a	16.3b	18.7bc	22.3d
Biomass (g.pot^{-})	26.67b	21.03a	21.03a	18.53a
Number of pods (.pot^{-})	11.7a	13.0a	13.0a	9.0a
Dry pods (g.pot^{-})	13.33b	13.10b	13.10b	9.33a
Dry seeds (g.pot^{-})	9.23a	10.07ab	10.07ab	6.97a

* NC, SS, MS, and BS respectively are the non-coated seeds, small coated seeds, medium coated seeds, and big coated seeds. The numbers in the same raw followed by the same letters indicate not significantly different based on its critical value of the $LSD_{\alpha=0.05}$ for each parameter.

There were different responses between the two varieties of groundnut to the seed coating treatment. For Lombok variety, the seed coating did not affect the number of pods but increased the weights of dry pods and seeds of SC and MS. For Kelinci variety, the seed treatment quadratically increased all of those components, and the maximum values were reached by the medium size of coated seeds (MC). These results suggested that the most appropriate weight ratios for the coated seeds of groundnut could be 1:6 to 1:9, or was 1:7.5 on average.

3.3. General Discussion

This research was the first attempt to find out an appropriate method of seed coating for food crops with organomineral fertilizer. So, knowing the causes of unsatisfied results of the coating was very important, enabling us to fix the seed coating method with organomineral fertilizer. Base on available data from this research, however, it was too difficult, if not impossible, to provide simple explanation about the primary causes of the decreases of growths and yields of both crops grown from the coated seeds.

The most noticeable cause was that the coated seeds required extra time for cracking the coating material before the seeds can germinate. Specific for the coated seeds of rice, an additional cause of decreasing the growth and grain yield was N-deficiency. However, those facts were most probably not the primary causes of decreasing the growth and yield of both crops.

The coating materials contained a high concentration of plant-essential nutrients, and most of those nutrients were in the soluble forms, especially urea and Orrin. This condition has brought to the thought that the coated seeds maybe toxified by the high concentration of nutrients dissolved from the coating materials. In this research, anticipation was made to avoid direct contact of the soluble nutrients with the seeds being coated, which was by applying urea or/and Orrin at the latest step in the application of the coating materials onto the seeds. But that effort seemed to be insufficient to avoid the toxifying the seeds by over-concentration of nutrients from the coating materials. Thus, the seed coating method described in this research needed some modification, especially for the composition of seed coating or/and binding materials, and the procedure of applying the coating materials onto the seed surface.

4. CONCLUSION AND RECOMMENDATION

The seed coating with the organomineral fertilizer consisting mainly of silicate rock fertilizer, rock phosphate, and organic matter delayed the seedling and decreased most of the growth and yield components of rice and groundnut. The seed coating method described in this research needed some modifications, of which especially were the composition of the coating or/and binding materials, and the procedure of applying the coating materials onto the seed surface.

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Original Research Article

Seed Coating with Organomineral Fertilizer, An Alternative Method to Improve the Efficiency of Farming

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ABSTRACT

Seed and fertilizer are two important farming inputs, which are commonly available and used separately. Combining both materials into a unit of fertilizer-coated seed may improve farming efficiency. However, the appropriate seed coating method must be found out, and this research was the first effort of finding the method. A glasshouse experiment was carried out to identify the growth and yield of the coated seeds of rice and groundnut with organomineral fertilizer in three different sizes (i.e., small (SS), medium (MS), and big sizes (BS). Four sets of experiments were prepared, two of those were for testing two varieties of rice, and the others were for testing two varieties of groundnut. Each experiment was laid out in a complete randomized design; the treatment was the size of coated seeds (SS, MS, BS, and a control - uncoated seeds) in triplicates. Results reveal that the seed coating delayed the germination of rice seeds for 2 – 3 days and groundnut seeds for 7 – 16 days, suppressed the growth and yield of rice but improved the growth and yield of groundnut. The highest yield of groundnut was the grown groundnut from the small and medium sizes of coated seeds (weight ratios of 1:4 and 1:9). The reduces of growth and yield of rice were most probably due to the direct contact of the high concentration of nutrients, especially nitrogen, with the seeds. In conclusion, the seed coating with organomineral fertilizer was a potentially developed method to improve farming efficiency. Further efforts were needed to fix the composition of organomineral fertilizer, especially the type N substances used, and the steps of applying the materials onto the seeds.

Keywords: organomineral fertilizer, coating materials, seed coating, silicate rock fertilizer

1. INTRODUCTION

Seed and fertilizer are two vital inputs in the farming of crops grown from seed, such as rice (*Oryza sativa* L.) and groundnut (*Arachis hypogaea* L.). The current issue of farming technology relating to the seeds is seed coating, and of that for fertilizer is the utilization of the natural sources of plant nutrients, including silicate rocks. Combining those farming inputs into a unit material of the coated seeds with the fertilizer may be an appropriate method to improve the productivity and profitability of the farming.

Seed coating is an important technology in agriculture that has been applied by seed industries for decades. The industries use various coating materials, and the most common one is pesticides [1]. The main aims of using pesticides are to suppress, control, or repel the soil-borne pathogens, insects, and other pests attacking seeds, seedlings, or plants [2, 3]. However, exposing pesticides into farming land may potentially develop pest resistance and create various negative-ecological effects [4]. Thus, it is a challenge for the seed industries to find out and use the more environmentally sound coating materials.

Fertilizer is another important farming input, used to fulfil the optimum requirement of crops for essential nutrients. The appropriate fertilizer application, referring to the ideal concept of proportional fertilization, however, is often difficult to be applied on the farm level, especially by small farmers in developing countries, due to technical or/and economic constraints. The high variability of soil properties, for example, may cause the difficulties to define the appropriate rate of fertilizer application; and the lack of farming capital often limits the small farmers to access the appropriate quantities of synthetic fertilizers. Responding to the cases, many researchers [5, 6, 7, 8] proposed the utilization of natural sources of plant-nutrients, e.g., silicate rocks, as cheap and environmentally sound fertilizer. However, the use of silicate rock fertilizers (SRFs) was limited in farming practices due to the very slow release of nutrients from the SRFs. Consequently, the farming required very high doses (> 20 $t.ha^{-}$) of SRFs [7]. However, by employing ball milling in producing SRFs [9, 10], or/and mixing SRFs with organic matter (termed as organomineral fertilizer), significantly improved the effectiveness of SRFs [11].

The limitations of the seed coating technology, especially in selecting the type of coating materials, and fertilizer application described above inspired us to propose combining the seed with organomineral fertilizer into the organomineral-coated seeds as an alternative solution for both farming constraints. The organomineral fertilizer consisted mainly of SRFs, rock phosphate (RP), and organic matters (OM), and those materials were coated onto the seeds, and the coating materials were functioned as the major nutrient source sufficient for fulfilling the optimum requirement of essential nutrients for the plants grown from the coated seeds without additional fertilizers. Besides reducing the farming costs (for fertilizers and labor) with less negative-environmental effects, planting the coated seeds may also improve soil quality due to the residual effects of the coating materials (organomineral fertilizer) remaining in the soil.

This research was the first attempt to evaluate if the proposed farming technology described above was realistic. The main objective of this research was to identify the effects of seed coating with organomineral fertilizer on the growth and yield components of rice (*Oryza sativa* L) and groundnut (*Arachis hypogaea* L).

2. MATERIAL AND

2.1. Seeds and Coating Materials

The seeds of two varieties of rice, i.e., Impari 32 and Bunda Sri Madrin (BSM), and two varieties of groundnut, i.e., Lombok and Kelinci, were prepared. The coating materials for rice seeds were SRF (87.5 % w/w), RP (4 % w/w), urea (4 % w/w), OM (2 % w/w), and liquid-foliar fertilizer (trademarked as Orrin) (2.5 % v/w). The SRF, RP, and OM were mixed, while urea was dissolved into Orrin that was functioned as the binding substance. The coating materials for groundnut seeds were the same as those for rice seeds, but the urea was substituted with $CaCO_3$ (4 % w/w) added to the mixture of SRFs + RP + OM, and the binding substance for the coated seeds was only Orrin.

The SRF was the finely ground basaltic rocks from Rinjani Mt. in Lombok Island – Indonesia. The rocks were mechanically broken to Ø < 1 cm and then ball-milled for 40 minutes producing the SRF-powder with the median diameter (D_{50}) $\leq$ 5.4 μm. The chemical composition of the SRF-powder was 54.22 % SiO_2, 25.01 % Al_2O_3, 5.00 % CaO, 1.90 %

4.44 % K_2O, 2.39 % Na_2O, 6.47 % FeO, 0.16 % MnO, 0.01 % ZnO, 0.31 % CuO, and < 0.10 % others. The RP (Ø < 0.5 cm) was ball-milled for 20 minutes producing RP-powder with the median diameter (D_{50}) $\leq$ 22 µm, and it contained a total of 16.8 % P_2O_5. The OM was the composted cattle wastes, screened to pass the 1-mm stainless steel screen. Urea and $CaCO_3$ respectively contained 44.2 % N and 38 % CaO. The liquid-foliar fertilizer (Orrin) contained of 4.04 % N, 3.22 % P_2O_5, 3.36 % K_2O, 0.32 % Ca, 0.40 % Mg, 0.12 % S, and 40, 122, 260, 10, 3, 0.1, and 1.2 $mg.L^-$ respectively of Fe, Mn, Zn, Cu, B, Co, and Mo.

2.2. Seed Coating Process

The seeds were coated using a rotating drum (350-L plastic drum), rotated with a 0.5-HP power machine at the speed of about 30 rpm. For coating the seeds of rice, 250-g seeds were coated with 2,500 g of the mixture of coating materials described above. In the first step, half of the mixed coating materials (SFR + RP + OM) were applied step-by-step onto the seed surface in the rotating drum, followed by spraying fresh water onto the seeds, forming the capsule-like coated seeds. Next, the other half of the coating materials were applied in the same way but using the binding substance of the urea + Orrin solution. The coated seeds were dried with a hairdryer (< 40^o C) in the rotating drum to avoid cracking of the coated seeds. Finally, the coated seeds were taken out from the drum, dried completely under sunray, and stored in a plastic container. The coating procedure for the seeds of groundnut was the same as that for rice seeds, but the coating material was the mixture of SRF + RP + OM + $CaCO_3$, and the binding material was Orrin applied in the second step of the seed coating process.

Due to the size variability of seeds within and between crop varieties, the coating processes produced various sizes and weight ratios of the seed to the coating material. Thus, the coated seeds were grouped into three size categories, i.e., small (SS), medium (MS), and big (BS) coated seeds for each variety, and the corresponding weight ratio (see Table 1).

Table 1. The size category and the weight ratio of seed to coating material

The size categories of coated seeds	Rice variety		Groundnut variety	
	Impari 32	BSM	Lombok	Kelinci
Small (SS)	1:10	1:8	1:4	1:6
Medium (MS)	1:20	1:15	1:6	1:9
Big (BS)	1:30	1:20	1:8	1:12

2.3. Experimental Setting

Four sets of experiments were prepared in a glasshouse; two sets were for testing the coated seeds of two varieties of rice (Impari 32 and BSM varieties), and the other two sets were for testing the coated seeds of two varieties of groundnut (Lombok and Kelinci varieties). A completely randomized experimental design was laid out for each set of experiments with a treatment consisting of uncoated seed (NC), small (SS), medium (MS), and big (BS) sizes of coated seeds, and those were triplicated. Nitrogen and phosphate fertilizers (2.0 $g.pot^-$ of N and 0.4 $g.pot^-$ of P_2O_5) were applied to the NC of rice; and phosphate fertilizer (0.4 $g.pot^-$ of P_2O_5) was applied to the NC of groundnut.

The soil used in this experiment was the 20-cm top of Ustipsamments of Akar-Akar, Northern Lombok, Indonesia, developed from pumice stones. The soil was air-dried and screened to pass a 2-mm stainless steel screen. The characteristics of the soil were sandy textured (4.2 % clay, 23.3 % silt, 74.5 % sand), neutral (pH_{H2O} 7.4), low N-total (0.02 % N), low phosphate (116 mg.kg$^-$ of Bray II-extractable P), low organic matter (1.9 % total C), low cation exchangeable capacity (4.8 cmol.kg$^-$), lack of exchangeable cations (0.69, 0.22, 1.6, and 1.5 cmol.kg$^-$ of K, Na, Ca, and Mg, respectively) and 0.01N acetic acid-extractable micronutrients (7.4, 1.2, and 1.3 mg.kg$^-$ of Fe, Cu, and Zn, respectively).

Sowing rice seeds: each pot was filled with 10-kg soil, saturated with deionized water (2 L.pot$^-$), mudded, and allowed to equilibrate overnight. Three seeds of rice were sown in each pot accordingly to the treatment at about 0.5-cm depth. After the young plants grew about 5-cm height, the water level in each pot was maintained at 1.5 – 5 cm accordingly to the growing stage of the plant. Rice was harvested at 105 days after sowing.

Sowing groundnut seeds: each pot was filled with 6-kg soil, moistened with deionized water to about field capacity (120 mL.pot$^-$), and allowed to equilibrate overnight. One seed was sown in each pot, accordingly to the treatment, at about 0.5-cm depth. Soil moisture was maintained to about field capacity. Groundnut was harvested at 95 days after sowing.

2.4. Statistical Analyses

The main collected data (parameters) were the germinating period of seeds and several components of growth and yield for each plant. The observed growth components for rice were the germinating period of seeds, number of tellers, and weight of dry biomass, and those for groundnut were the germinating period of seeds and dry biomass. The yield component for rice was dry grain, and for groundnut were the number of pods, the weight of total pods, and weight of total seeds (kernels). The analysis of variance (ANOVA) was carried out, and the test of the least significant difference (LSD) at $\alpha = 0.05$ was applied to the appropriate parameters (which were significantly affected by the treatment).

3. RESULTS AND DISCUSSION

3.1. The Growth and Yield of Rice

Statistically, the seed coating with organomineral fertilizer significantly increased the days required by the coated seeds to germinate, reduced the growth and yield components of both rice varieties (Table 2). It was also noticeable (data were not shown) that the plants of the coated seeds were most probably deficient of N, indicated by the yellowish-green of most leaves, starting in the third weeks after sowing. It was an important finding or reference for further improvement of the seed coating procedure that the concentration of N in the coating materials for rice seeds should be higher than applied in this experiment.

As shown in Table 2, the non-coated seeds (NC) germinated in six to seven days, while the coated seeds were in about teen to thirteen days after sowing; and the bigger the size, the more days required by the coated seeds to germinate. Inversely, for each rice variety, the bigger the size of coated seeds, the lower the number of tellers and the weights of biomass and grain yield.

The delay of germination for the coated seeds was most probably due to the coated seeds required extra time for cracking the coating materials surrounding the seed surface. Our visual observation indicated that in the water-saturated or mudded soil, the coating materials on the surface of rice seeds started to crack in one to three days after sowing.

Table 2. The effects of seed coating on the growth and yield components of rice

Variety and Parameter	Seed Treatment*			
	NC	SS	MS	BS
Impari 32:				
a. Germination (days)	6.3a	10.0b	11.3b	11.7b
b. Number of tellers (.pot^{-})	15.0b	17.3b	10.7a	11.0a
c. Dry biomass (g.pot^{-})	29.94c	29.12c	15.71b	6.77a
d. Dry grains (g.pot^{-})	39.07c	39.27c	34.93b	29.77a
Bunda Sri Madrin (BSM):				
a. Germination (days)	7.0a	10.3b	11.0b	12.7c
b. Number of tellers (.pot^{-})	18.7c	13.7b	11.0a	9.3a
c. Dry biomass (g.pot^{-})	25.43c	16.54ab	19.90b	15.16a
d. Dry grains (g.pot^{-})	37.57b	35.87b	31.50a	29.17a

* NC, SS, MS, and BS respectively are the non-coated seeds, small coated seeds, medium coated seeds, and big coated seeds, referring to the weight ratios described in Table 1. The numbers in the same raw, followed by the same letters indicate not significantly different based on the critical value of the $LSD_{\alpha=0.05}$ for each parameter.

3.2. The Growth and Yield of Groundnut

The effects of the seed coating with organomineral fertilizer on the growth and yield components of groundnut are presented in Table 3. The seed coating depressed the germination of both varieties of groundnut, and the larger the coating size, the more time required by groundnut seeds to germinate. Inversely, the coating treatment tended to decrease the other growth and yield components.

Table 3. The effects of seed coating on the growth and yield components of groundnut

Variety and Parameter	Seed Treatment*			
	NC	SS	MS	BS
Lombok:				
Germination (days)	7.7a	13.3a	14.7bc	17.7c
Biomass (g.pot-)	27.20b	17.47a	20.17a	18.53a
Number of pods (.pot^{-})	18.3	16.0	18.0	14.7
Dry pods (g.pot^{-})	16.00b	18.10b	18.30b	11.67a
Dry seeds (g.pot^{-})	12.60ab	15.43b	13.10ab	9.30a
Kelinci:				
Germination (days)	7.3a	16.3b	18.7bc	22.3d
Biomass (g.pot^{-})	26.67b	21.03a	21.03a	18.53a
Number of pods (.pot^{-})	11.7a	13.0a	13.0a	9.0a
Dry pods (g.pot^{-})	13.33b	13.10b	13.10b	9.33a
Dry seeds (g.pot^{-})	9.23a	10.07ab	10.07ab	6.97a

* NC, SS, MS, and BS respectively are the non-coated seeds, small coated seeds, medium coated seeds, and big coated seeds, referring to the weight ratios described in Table 1. The numbers in the same raw followed by the same letters indicate not significantly different based on the critical value of the $LSD_{\alpha=0.05}$ for each parameter.

As shown in Table 3, the uncoated seeds (NC) of groundnut germinated in 7 - 8 days, whereas the coated seeds germinated in 13 – 23 days after sowing, and the ticker (bigger) the coated seeds, the more time required by the coated seeds to germinate.

There were different responses between the two varieties of groundnut to the seed coating treatment. For Lombok variety, the seed coating did not affect the number of pods but increased the weights of dry pods and seeds of SS and MS. For Kelinci variety, the seed treatment quadratically increased all of those components, and the maximum values were reached by the medium size of coated seeds (MS). These results suggested that each variety of groundnut having a specific size or weight of seed required a certain optimum amount of coating material. For Lombok and Kelinci varieties, the appropriate rage of weight ratios for the coated seeds was 1:6 to 1:9, or 1:7.5 on average.

3.3. General Discussion

This research was the first attempt to find out an appropriate method of seed coating for food crops with organomineral fertilizer. So, knowing the causes of unsatisfied results of the coating was very important, enabling us to fix the seed coating method with organomineral fertilizer in the further development of the seed coating. Base on available data from this research, however, it was too difficult, if not impossible, to provide a simple explanation about the primary causes of the decreases of growths and yields of both crops grown from the coated seeds.

The most noticeable cause was that the coated seeds required extra time for cracking the coating material before the seeds can germinate. Specific for the coated seeds of rice, an additional cause of decreasing the growth and grain yield was N-deficiency. However, those facts were most probably not the primary causes of decreasing the growth and yield of both crops.

The coating materials contained a high concentration of plant-essential nutrients, and urea and Orrin were very soluble substances. This condition had brought to the thought that the coated seeds were toxified by the high concentration of nutrients dissolved from the coating materials and directly contacting to the seed surface. In this research, anticipation was made to avoid the direct contact of soluble nutrients with the seeds being coated, which was by applying urea or/and Orrin at the latest step in the application of the coating materials onto the seeds. But that effort seemed to be insufficient to avoid the toxifying the seeds by over-concentration of nutrients from the coating materials. Thus, the seed coating method described in this research needed some modification, especially for the composition of seed coating or/and binding materials, and the procedure of applying the coating materials onto the seed surface.

4. CONCLUSION AND RECOMMENDATION

The seed coating with the organomineral fertilizer consisting mainly of silicate rock fertilizer, rock phosphate, and organic matter delayed the seedling and decreased most of the growth and yield components of rice but improved of the yield of groundnut. The seed coating with organomineral fertilizer described in this research was potentially developed as an appropriate technology to improve farming efficiency but needed further development. Some modifications must be made, especially for the composition of seed coating or/and binding materials and the procedure of applying the coating materials onto the seed surface.

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Manuscript Number:	**Ms_ARJA_52771**
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Minor REVISION comments	Please, review the phrase: "those materials were coated onto the seeds and intended to sufficiently fulfill the optimum requirement of essential nutrients for the without additional fertilizers" The composition on the sentence "The chemical composition of the SRF-powder was 52.28 % SiO_2, 24.12 % Al_2O_3, 4.82 % CaO, 1.83 % 4.28 % K_2O, 2.30 % Na_2O, 6.24 % FeO, 0.15 MnO, 0.01 % ZnO, 0.30 % CuO, and < 0.01 % others" raises only 93.33%. Suggestion: comment on the other possible substances. The sentence "The RP (Ø < 0.5 cm) was ball-milled for 20 minutes producing PR-powder with the median diameter (D_{50}) ≤ 22 μm, and it contained a total of 16.8 % P_2O_5". I believe it is PR (Ø < 0.5 cm) The phrase "low phosphate (116 mg.kg- of P by Bray-II), low organic matter (1.9 % total C), low CEC …" – it is uncommon use acronym without quote the expression. Furthermore, I believe it was only compatibility problem of Word Program, but all superscript does not appear on my text. I advise to check upon. Moreover "increased the weights of dry pods and seeds of SC and MS. For Kelinci variety, the seed treatment quadratically increased all of those components, and the maximum values were reached by the medium size of coated seeds (MC)" – I believe it is SS and MS (as quoted on Table 3) Suggestion – "Table 1. The size category and the weight ratio of seed to coating material" comment about fertilizer amount (roughly 1:10). I think it is important to emphasize that.	Yes,..I see the mistakes and those are fixed in the revised manuscript. Thanks It is common that the total composition of the analysed material (rocks) using XRF or AAS is less than 100 % (some loss due to ignition), and can be normalized into the total of 100 %, and I correct the highlighted numbers by normalizing those values to total 100 %. OK..changing PR to RP. Initially, I use the term of 'phosphatic rocks (PRs) to indicate that any phosphate rocks or material containing phosphate may be used in the seed coating. Other comments are OK, fixed.
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Seed Coating with Organomineral Fertilizer, an Alternative Method to Improve the Efficiency of Farming

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Authors' contributions

This work was carried out in collaboration between both authors. Author JP designed the study, technical aspects of seed coating, constructs the outline and wrote the first draft of the manuscripts. Author AAKS performed the statistical analysis, managed the literature searches for seed treatments. Both authors read and approved the final manuscript.

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ABSTRACT

Seed and fertilizer are two important farming inputs, which are commonly available and used separately. Combining both materials into a unit of fertilizer-coated seed may improve farming efficiency. Technically, however, the appropriate seed coating method must be found out, and this research was the first effort of finding the method. A glasshouse experiment was carried out to identify the growth and yield of the coated seeds of rice and groundnut with organomineral fertilizer in three different sizes (i.e., small (SS), medium (MS), and big sizes (BS). Four sets of experiments were prepared, two of those were for testing two varieties of rice, and the others were for testing two varieties of groundnut. Each experiment was laid out in a complete randomized design; the treatment was the size of coated seeds (SS, MS, BS, and a control - uncoated seeds) in triplicates. Results reveal that the seed coating delayed the germination of rice seeds for 2 – 3 days and

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groundnut seeds for 7 – 16 days. The coating also suppressed the growth and yield of rice but improved the growth and yield of groundnut. The coated seeds of groundnut producing the higher yield were the small and medium sizes (the weight ratios of seed:coating material were 1:4 and 1:9). In case of rice seeds, the reduces of growth and yield of the coated seeds were most probably due to the direct contact of the high concentration of nutrients, especially nitrogen, dissolved from the coating material with the seeds. In conclusion, the seed coating with organomineral fertilizer improve the yield of groundnut, and the best coating was in small to medium sizes. Especially for coating the rice seeds, further efforts were needed to fix the composition of organomineral fertilizer, especially the type N substances used, and the steps of applying the materials onto the seeds.

Keywords: Organomineral fertilizer; coating materials; seed coating; silicate rock fertilizer

1. INTRODUCTION

Seed and fertilizer are two vital inputs in the farming of crops grown from seed, such as rice (*Oryza sativa* L.) and groundnut (*Arachis hypogaea* L.). The current issue of farming technology relating to the seeds is seed coating, and of that for fertilizer is the utilization of the natural sources of plant nutrients, including silicate rocks. Combining those farming inputs into a unit material, which is coating the seeds with the fertilizer, may be an appropriate method to improve the productivity and profitability of the farming.

Seed coating is an important technology that has been applied by seed industries for decades. The industries use various coating materials, and the most common one is pesticides [1]. The main aims of using pesticides are to suppress, control, or repel the soil-borne pathogens, insects, and other pests attacking seeds, seedlings, or plants [2,3,4]. However, exposing pesticides into farming land may potentially develop pest resistance and create various negative-ecological effects [5]. Thus, it is a challenge for the seed industries to find out and use the more environmentally sound coating materials.

Fertilizer is another important farming input, used to fulfill the optimum requirement of crops for essential nutrients. The appropriate fertilizer application, referring to the ideal concept of proportional fertilization, however, is often difficult to be applied on the farm level, especially by small farmers in developing countries, due to technical or/and economic constraints. The high variability of soil properties, for example, may cause the difficulties to define the appropriate rate of fertilizer application; and the lack of farming capital often limits the small farmers to access the appropriate quantities of synthetic fertilizers. Responding to the cases, many researchers [6,7,8,9,10] proposed the utilization of natural sources of plant-nutrients, e.g., silicate rocks, as cheap and environmentally sound fertilizer [11,12]. However, the use of silicate rock fertilizers (SRFs) was limited in farming practices due to the very slow release of nutrients from the SRFs. Consequently, the farming required very high doses (> 20 $t.ha^{-}$) of SRFs [8]. However, by employing ball milling in producing SRFs [13,14], or/and mixing SRFs with organic matter (organomineral fertilizer), significantly improved the effectiveness of SRFs [15].

The limitations of the seed coating and fertilizer application described above inspired us to propose combining the seed with organomineral fertilizer into the organomineral-coated seeds as an alternative solution for the farming constraints. The organomineral fertilizer consisted mainly of SRFs, phosphatic rocks (PRs), and organic matters (OM), and those materials were coated onto the seeds and intended to sufficiently fulfill the optimum requirement of essential nutrients for the without additional fertilizers. Planting the organomineral-coated seeds maybe also reduce the farming cost with less negative-environmental effects, and improve soil quality due to the residual effects of the coating materials (organomineral fertilizer) remaining in the soil.

This research was the first attempt to evaluate if the proposed farming method described above was realistic. The main objective of this research was to identify the effects of seed coating with organomineral fertilizer on the growth and yield components of rice (*Oryza sativa* L) and groundnut (*Arachis hypogaea* L).

2. MATERIALS AND METHODS

2.1 Seeds and Coating Materials

The seeds of two varieties of rice, i.e., Impari 32 and Bunda Sri Madrin (BSM), and two varieties of groundnut, i.e., Lombok and Kelinci, were prepared. The coating materials for rice seeds were SRF (87.5% w/w), PR (4% w/w), urea (4% w/w), OM (2% w/w), and liquid-foliar fertilizer (trademarked as Orrin) (2.5% v/w). The SRF, PR, and OM were mixed, while urea was dissolved into Orrin that was functioned as the binding substance. The coating materials for groundnut seeds were the same as those for rice seeds, but the urea was substituted with $CaCO_3$ (4% w/w) added to the mixture of SRFs + PRs + OM, and the binding substance for the coated seeds was only Orrin.

The SRF was the finely ground basaltic rocks from Rinjani Mt. in Lombok Island – Indonesia. The rocks were mechanically broken to Ø < 1 cm and then ball-milled for 40 minutes producing the SRF-powder with the median diameter (D_{50}) $\leq$ 5.4 µm. The chemical composition of the SRF-powder was 52.28% SiO_2, 24.12% Al_2O_3, 4.82% CaO, 1.83% 4.28% K_2O, 2.30 % Na_2O, 6.24% FeO, 0.15 MnO, 0.01% ZnO, 0.30% CuO, and < 0.01% others. The RP (Ø < 0.5 cm) was ball-milled for 20 minutes producing PR-powder with the median diameter (D_{50}) $\leq$ 22 µm, and it contained a total of 16.8% P_2O_5. The OM was the composted cattle wastes, screened to pass the 1-mm stainless steel screen. Urea and $CaCO_3$ respectively contained 44.2% N and 38% CaO. The liquid-foliar fertilizer (Orrin) contained of 4.04% N, 3.22 % P_2O_5, 3.36% K_2O, 0.32% Ca, 0.40% Mg, 0.12% S, and 40, 122, 260, 10, 3, 0.1, and 1.2 mg.L- respectively of Fe, Mn, Zn, Cu, B, Co, and Mo.

2.2 Seed Coating Process

The seeds were coated using a rotating drum (350-L plastic drum), rotated with a 0.5-HP power machine at the speed of about 30 rpm. For coating the seeds of rice, 250-g seeds were coated with 2,500 g of the mixture of coating materials described above. In the first step, half of the mixed coating materials (SFRs + PRs + OM) were applied step-by-step onto the seed surface in the rotating drum, followed by spraying fresh water onto the seeds, forming the capsule-like coated seeds. Next, the other half of the coating materials were applied in the same way but using the binding substance of the urea + Orrin solution. The coated seeds were dried with a hairdryer (< 40°C) in the rotating drum to avoid cracking of the coated seeds. Finally, the coated seeds were taken out from the drum, dried completely under sunray, and stored in a plastic container. The coating procedure for the seeds of groundnut was the same as that for rice seeds, but the coating material was the mixture of SRFs + PRs + OM + $CaCO_3$, and the binding material was Orrin applied in the second step of the seed coating process.

Due to the size variability of seeds within and between crop varieties, the coating processes produced various sizes and weight ratios of the seed to the coating material. Thus, the coated seeds were grouped into three size categories, i.e., small (SS), medium (MS), and big (BS) coated seeds for each variety, and the corresponding weight ratio (see Table 1).

2.3 Experimental Setting

Four sets of experiments were prepared in a glasshouse; two sets were for testing the coated seeds of two varieties rice (Impari 32 and BSM varieties), and the other two sets were for testing the coated seeds of two varieties of groundnut (Lombok and Kelinci varieties). A completely randomized experimental design was laid out for each set of experiments with a treatment consisting of uncoated seed (NC), small (SS), medium (MS), and big (BS) sizes of coated seeds, and those were triplicated. Nitrogen and phosphate fertilizers (2.0 $g.pot^-$ of N and $0.4.pot^-$ of P_2O_5) were applied to the NC of rice; and phosphate fertilizer (0.4 g pot^- of P_2O_5) was applied to the NC of groundnut. The soil used in this experiment was the 20-cm top of Ustipsamments of Akar-Akar, Northern Lombok, Indonesia, developed from pumice stones. The soil was air-dried and screened to pass a 2-mm stainless steel screen. The characteristics of the soil were sandy textured (4.2% clay, 23.3% silt, 74.5% sand), neutral (pH_{H2O} 7.4),

Table 1. The size category and the weight ratio of seed to coating material

The size categories of coated seeds	Rice		Groundnut	
	Impari 32	BSM	Lombok	Kelinci
Small (SS)	1:10	1:8	1:4	1:6
Medium (MS)	1:20	1:15	1:6	1:9
Big (BS)	1:30	1:20	1:8	1:12

low N-total (0.02% N), low phosphate (116 mg.kg^{-} of P by Bray-II), low organic matter (1.9 % total C), low CEC (4.8 cmol.kg^{-}), lack of exchangeable cations (0.69, 0.22, 1.6, and 1.5 cmol.kg^{-} of K, Na, Ca, and Mg, respectively) and extractable micronutrients (7.4, 1.2, and 1.3 mg.kg^{-} of Fe, Cu, and Zn, respectively).

Planting rice: each pot was filled with 10-kg soil, saturated with deionized water (2 L.pot^{-}), mudded, and allowed to equilibrate overnight. Three seeds of rice were planted in each pot accordingly to the treatment at about 0.5-cm depth. After the young plants grew about 5-cm height, the water level in each pot was maintained at 1.5 – 5 cm accordingly to the growing stage of the plant. Rice was harvested at 105 days after planting.

Planting groundnut: each pot was filled with 6-kg soil, moistened with deionized water to about field capacity (120 mL. pot^{-}), and allowed to equilibrate overnight. One seed was planted in each pot, accordingly to the treatment, at about 0.5-cm depth. Soil moisture was maintained to about field capacity. Groundnut was harvested at 95 days after planting.

2.4 Statistical Analyses

The main collected data (parameters) were the germinating period of seeds and several components of growth and yield for each plant. The analyses of variance (ANOVA) were carried out, and the tests of the least significant difference (LSD) at $\alpha = 0.05$ were applied to the appropriate sets of data (significantly different based on the ANOVA).

3. RESULTS AND DISCUSSION

3.1 The Growth and Yield of Rice

Statistically, the seed coating with organomineral fertilizer significantly increased the days required by the coated seeds to germinate, reduced the growth and yield components of both rice varieties (Table 2). It was also noticeable (data were not shown) that the plants of the coated seeds were most probably deficient of N, indicated by the yellowish-green of most leaves, starting in the third weeks after planting.

As shown in Table 2, the non-coated seeds (NC) germinated in six to seven days, while the coated seeds were in about teen to thirteen days after planting; and the bigger the size, the more days required by the coated seeds to germinate. Inversely, for each rice variety, the bigger the size of coated seeds, the lower the number of tellers and the weights of biomass and grain yield.

The delay of germination for the coated seeds was most probably due to the coated seeds required extra time for cracking the coating materials surrounding the seed surface. Our visual observation indicated that in the water-saturated or mudded soil, the coating materials on the surface of rice seeds started to crack in one to three days after planting.

3.2 The Growth and Yield of Groundnut

The effects of the seed coating with organomineral fertilizer on the growth and yield components of groundnut are presented in Table 3. The seed coating depressed the germination of both varieties of groundnut, and the larger the coating size, the more time required by groundnut seeds to germinate. Inversely, the coating treatment tended to decrease the other growth and yield components.

As shown in Table 3, the uncoated seeds (NC) of groundnut germinated in 7 - 8 days, whereas the coated seeds germinated in 13 – 23 days after planting, and the ticker (bigger) the coated seeds, the more time required by the coated seeds to germinate.

There were different responses between the two varieties of groundnut to the seed coating treatment. For Lombok variety, the seed coating did not affect the number of pods but increased the weights of dry pods and seeds of SC and MS. For Kelinci variety, the seed treatment quadratically increased all of those components, and the maximum values were reached by the medium size of coated seeds (MC). These results suggested that the most appropriate weight ratios for the coated seeds of groundnut could be 1:6 to 1:9, or was 1:7.5 on average.

3.3 General Discussion

This research was the first attempt to find out an appropriate method of seed coating for food crops with organomineral fertilizer. So, knowing the causes of unsatisfied results of the coating was very important, enabling us to fix the seed coating method with organomineral fertilizer.

Base on available data from this research, however, it was too difficult, if not impossible, to provide simple explanation about the primary causes of the decreases of growths and yields of both crops grown from the coated seeds.

The most noticeable cause was that the coated seeds required extra time for cracking the coating material before the seeds can germinate. Specific for the coated seeds of rice, an additional cause of decreasing the growth and grain yield was N-deficiency. However, those facts were most probably not the primary causes of decreasing the growth and yield of both crops.

The coating materials contained a high concentration of plant-essential nutrients, and most of those nutrients were in the soluble forms, especially urea and Orrin. This condition has brought to the thought that the coated seeds maybe toxified by the high concentration of nutrients dissolved from the coating materials. In this research, anticipation was made to avoid direct contact of the soluble nutrients with the seeds being coated, which was by applying urea or/and Orrin at the latest step in the application of the coating materials onto the seeds. But that effort seemed to be insufficient to avoid the toxifying the seeds by over-concentration of nutrients from the coating materials. Thus, the seed coating method described in this research needed some modification, especially for the composition of seed coating or/and binding materials, and the procedure of applying the coating materials onto the seed surface.

Table 2. The effects of seed coating on the growth and yield components of rice

Variety and Parameter	Seed Treatment*			
	NC	SS	MS	BS
Impari 32:				
a. Germination (days)	6.3a	10.0b	11.3b	11.7b
b. Number of tellers (.pot^{-})	15.0b	17.3b	10.7a	11.0a
c. Dry biomass (g.pot^{-})	29.94c	29.12c	15.71b	6.77a
d. Dry grains (g.pot^{-})	39.07c	39.27c	34.93b	29.77a
Bunda Sri Madrin (BSM):				
a. Germination (days)	7.0a	10.3b	11.0b	12.7c
b. Number of tellers (.pot^{-})	18.7c	13.7b	11.0a	9.3a
c. Dry biomass (g.pot^{-})	25.43c	16.54ab	19.90b	15.16a
d. Dry grains (g.pot^{-})	37.57b	35.87b	31.50a	29.17a

** NC, SS, MS, and BS respectively are the non-coated seeds, small coated seeds, medium coated seeds, and big coated seeds. The numbers in the same raw, followed by the same letters indicate not significantly different based on its critical value of the $LSD_{\alpha=0.05}$ for each parameter*

Table 3. The effects of seed coating on the growth and yield components of groundnut

Variety and Parameter	Seed Treatment*			
	NC	SS	MS	BS
Lombok:				
Germination (days)	7.7a	13.3a	14.7bc	17.7c
Biomass (g.pot-)	27.20b	17.47a	20.17a	18.53a
Number of pods (.pot^{-})	18.3	16.0	18.0	14.7
Dry pods (g.pot^{-})	16.00b	18.10b	18.30b	11.67a
Dry seeds (g.pot^{-})	12.60ab	15.43b	13.10ab	9.30a
Kelinci:				
Germination (days)	7.3a	16.3b	18.7bc	22.3d
Biomass (g.pot^{-})	26.67b	21.03a	21.03a	18.53a
Number of pods (.pot^{-})	11.7a	13.0a	13.0a	9.0a
Dry pods (g.pot^{-})	13.33b	13.10b	13.10b	9.33a
Dry seeds (g.pot^{-})	9.23a	10.07ab	10.07ab	6.97a

** NC, SS, MS, and BS respectively are the non-coated seeds, small coated seeds, medium coated seeds, and big coated seeds. The numbers in the same raw followed by the same letters indicate not significantly different based on its critical value of the $LSD_{\alpha=0.05}$ for each parameter*

4. CONCLUSION AND RECOMMENDATION

The seed coating with the organomineral fertilizer consisting mainly of silicate rock fertilizer, rock phosphate, and organic matter delayed the seedling and decreased most of the growth and yield components of rice and groundnut. The seed coating method described in this research needed some modifications, of which especially were the composition of the coating or/and binding materials, and the procedure of applying the coating materials onto the seed surface.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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